

Pioneer Venus 1978 Mission Support

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The Ground Data System configuration for support of the Pioneer Venus 1978 Mission is described. Current status of the DSN portion of the Ground Data System is described.

I. Introduction

The telemetry and command portion of the Ground Data System which will be used to support the Pioneer Venus 1978 mission is described schematically in Fig. 1. Pictured is the usual telemetry and command configuration for the transit phase of the mission and for orbital operations. There will be a single telemetry stream in all transit and orbital phases of the mission, except for a brief period of Probe checkout in transit to Venus when a second subcarrier will be present containing Probe data.

The station configuration will be the standard multimission Mark III-DSN data subsystems configuration. Pioneer Venus will not, however, utilize the new "store-and-forward" mode of Command System operation. All telemetry data in the standard mission will be long constraint length, convolutionally encoded. Command and telemetry data will flow via standard NASCOM high-speed data circuits to the Pioneer Mission Operations Control Center (PMOCC) located at Ames Research Center. At Ames Research Center (ARC), real-time telemetry processing takes place in a Sigma 5 computer, and

incoming high-speed data is logged. The Command System at Ames Research Center operates in a PDP-11 computer.

As the data passes through the West Coast Switching Center located at JPL in Pasadena, it will also be routed to the Network Operations Control Center where proper operation of the DSN portion of the Command and Telemetry Systems will be monitored. In addition, the DSN will be producing a log of the telemetry data and producing an Intermediate Data Record as a non-real-time deliverable to the Flight Project. The Intermediate Data Record will be shipped to Ames Research Center, where its contents can be merged with data logged in real-time in the PMOCC and where the Project will produce the Master Data Record (MDR) and with further processing produce the Experimenter Data Records (EDR) for delivery to the experimenters.

The Ground Data System interfaces between the DSN and ARC are, therefore, high-speed data circuits for the real-time data flow, voice circuits for coordination of operations, and an Intermediate Data Record of all recoverable telemetry.

The Tracking System portion of the Ground Data System does not directly involve Ames Research Center. The data flow would look identical to Fig. 1 for the path from the tracking station through the Intermediate Data Record (IDR) interface, with the navigation function at JPL being substituted for Ames Research Center as the recipient of the IDR.

There are three other elements of the Ground Data System which will be discussed separately below: the configuration for support of the Orbiter occultations, the configuration for support of telemetry recovery for the Multiprobe entry, and the configuration for support of the Multiprobe Wind Measurement Experiment.

II. Status of the DSN-GDS Interfaces: Cruise and Orbit

In December 1976, the high-speed data circuits used in support of Pioneer 6 through 11 were converted from 4800 to 7200 bits per second. This is significant for Pioneer Venus since this change gives enough margin on the high-speed data line capacity to enable making the Pioneer Venus high-speed data blocks for telemetry frame-synchronous. Each telemetry high-speed data block for Pioneer Venus will contain a single 512-bit telemetry frame. Note that all Pioneer Venus telemetry formats are the same 512-bit frame length and format changes will be transparent to the DSN.

The Ground Data System configuration being used to support Pioneer 10 and 11 looks essentially identical to that shown for Pioneer Venus in Fig. 1, except that an Intermediate Data Record is not currently produced for Pioneer 10 and 11. The current data record interface is to utilize the log tape produced by the PMOCC real-time system with Ames directly recalling missing data from the tracking stations to produce a Master Data Record of sufficient quality. It is planned to convert all previous Pioneers to the Intermediate Data Record interface in December 1977, coincident with the start of Ground Data System testing for Pioneer Venus.

Current high-speed data formats include a 33-bit error code used to detect errors in transmissions in real-time. The DSN has long-term plans to implement an error-correcting high-speed data system which will automatically retransmit high-speed data blocks found to be in error. This new system will require a new error code of 22 bits which requires a change in the high-speed data format. It was desirable to implement this change in high-speed data format prior to the start of Pioneer Venus testing in order to avoid having to implement two different formats for Pioneer Venus and changing format during the mission. Therefore, it was negotiated to convert all Pioneers to the new high-speed data format in February 1978, and to support Pioneer Venus testing starting in November

1977 in the new format. It was discovered, however, that this plan was inconsistent with the Navigation interface in that the Mission Control and Computing Center computer involved in the existing Navigation interface would not be able to handle the new high-speed data formats. There was an original plan to go to a new DSN Navigation interface for all missions in May 1978. This new DSN Navigation interface eliminates the Mission Control and Computing Center 360/75 computer from the radio metric data flow and involves the delivery of a radio metric Intermediate Data Record from the DSN directly to the Navigation computers. This scheduling incompatibility problem was solved by negotiating an earlier availability of the new interface in order to support Pioneer Venus prelaunch testing. The new interface will be operational by February 1978.

III. Configuration for Pioneer Venus Orbiter Occultation Support

Pioneer Venus will have periastron Earth occultations on the order of the first 80 days of Venusian orbit. These occultations will be in the mutual view period of DSS 14 and 43 (Goldstone and Australian 64-meter stations). The first few occultations will be visible from only a single station until the orbit can be trimmed and synced up with the 2-station overlap period. The large number of Venusian occultations involved in Pioneer Venus made it impractical to utilize the configuration used to support all previous planetary occultations.

The usual method of supporting an occultation has been to make analog recordings of the output of an open-loop receiver whose bandwidth is wide enough to cover all the frequency changes that take place during the time span of interest. These analog recordings were then shipped to JPL, where the DSN digitized the recordings in the Compatibility Test Area. The digitized recordings were then delivered to the experimenter, who would then do a first step processing termed decimation.

The decimation process involves bandwidth reduction by multiplying the wide-bandwidth signal by an estimate of that signal and then filtering the product to remove that portion of the bandwidth which no longer contains any information. The problem in the case of Pioneer Venus is that the total shift at S-band for a Venusian occultation is on the order of 100 kHz. Pioneer Venus will also have X-band for the occultations, which would then be on the order of 400 kHz. This wide bandwidth meant that each analog recording would turn into many digitized tapes and that the processing by the experimenter to do the decimation was excessively expensive and time consuming.

A DSN team was formed in May 1976 to study ways to solve this problem as well as the problem of providing the interface with Massachusetts Institute of Technology for the Wind Measurement Experiment (described in Ref. 2). The functional concept of solving the occultation problem was accepted both by OTDA and the Project in June 1976. The resulting configuration, which will be implemented at DSS 14 and 43 for Pioneer Venus, is shown in Fig. 2.

The decimation process briefly described above can be accomplished in either a digital or analog fashion. The configuration shown in Fig. 2 is an analog approach. Instead of the open-loop receiver being driven by a fixed LO, a computer-controlled programmable local oscillator will be used to drive the first LO in the open-loop receivers to approximate the expected signal. This will enable using a much narrower bandwidth so that the signals can be analog-to-digital converted in real-time, and the resulting data rate will be low enough to be accommodated on a conventional computer-compatible recording. The configuration requires the implementation of an additional minicomputer at both stations in order to control the programmable local oscillator as well as do the formatting of the tape recording.

The operation of the system requires that an estimate of the expected signal be available for programming of the local oscillator. This requires the addition of a Venusian atmospheric model in the Navigation-to-DSN predict interface. The result will be predicted doppler, including atmospheric effects, which will be used to compute a series of linear ramps which will be programmed into the minicomputer to drive the programmable local oscillator.

It is intended that the standard interface with the experimenters will be the replay of the computer-compatible Original Data Record on-site over high-speed data lines back to the NOCC for production of an open-loop radio science Intermediate Data Record by the DSN. It will also be possible, when warranted, to directly ship the computer-compatible tapes to the NOCC for conversion to the Intermediate Data Record format.

A cost problem developed in the implementation of the occultation support system in the planned use of an integration contractor for constructing the system. The first proposal from the integration contractor was many times higher than the planned budget for the system. This problem has been negotiated by clarifying the requirements with the contractor and by pulling certain portions of the work back in-house. Although the schedule is tight, it is planned to have this configuration operable at Stations 14 and 43 by July 1, 1978, to give five months of operational system checkout and test and training. DSS 63 will also be provided with an occultation

support system since some Mariner Jupiter-Saturn occultations will be visible from that station.

IV. Multiprobe Entry Configuration and Status

The Multiprobe entry operations and support strategy are described in Ref. 1. Figure 3 shows the configuration for the telemetry data recovery and the interferometry Wind Measurement Experiment for the Multiprobe entry. This is an update of the drawing which appeared in Ref. 1. There are two principal changes since the time of writing of the reference: The interferometry experiment now requires a separate receiver, and the requirement for symbol recordings at the tracking stations has been deleted.

The original configuration involved sharing the Differential Long Baseline Interferometry Experiment (DLBI) function with one of the open-loop receivers which are being provided for precarrier detection telemetry recovery. Detailed design work on meeting the stringent DLBI experiment relative phase accuracy requirements led to the need for providing a separate special-purpose receiver for the experiment. The status of the DLBI experiment, including the support by two STDN tracking stations, was covered in great detail in Ref. 2. The only change in status since the writing of Ref. 2 is that a cost problem developed when the bid for the operational high-rate digital recorders came in 50% over plan. This problem was solved by deleting several desired multimission features from the recorders which do not directly affect the Pioneer Venus requirements, by delaying one of the transports for both Station 14 and 43 until FY-78, and by deleting the second recorder for CTA-21 for the tape conversion facility.

Originally it was thought that since each Telemetry Processor Assembly (TPA) contains only a single sequential decoder, there would be a capability for only two real-time probe streams from each station, and therefore a means of recording the soft decisions out of the Symbol Synchronizer Assembly would have to be provided to provide a "loss-less" digital recording for two of the four streams. It has turned out that since the sequential decoders which are provided within the main frame of the TPA computers are 4 to 5 times faster than the sequential decoders which were used for Pioneer 10 and 11 support, it will be possible to take advantage of this speed and produce software for the TPA which can handle two low-rate sequentially decoded streams simultaneously. It is, therefore, the current implementation plan to provide special software in the TPA for support of the Multiprobe entry in order to support two low-rate sequentially decoded streams simultaneously. This capability is currently scheduled for late summer of 1977.

A recent addition to the requirement for precarrier detection telemetry recovery is the requirement for the DSN to play the analog recordings backward into a closed-loop telemetry string at CTA-21 to produce a digital recording of the soft decisions out of the Symbol Synchronizer Assembly. Preliminary DSN testings make this backward playback look feasible with a minimal additional performance loss. The Project will develop "backward" sequential decoding software at Ames to process this data.

Also shown in Fig. 3 is a Multiprobe entry simulator which will be used to train the station operators for the Multiprobe entry event. This system has undergone a detailed design review and will enable simulating all four probes' signals simultaneously, including modulation changes, bit rate changes, and approximate doppler profiles. The system involves an analog tape recording of the four telemetry data streams (data plus subcarrier), which will be read into the Multiprobe entry simulator. The recorded tape will control the bit rates, and the start time on the tape will control the start

of the sequencing in the Multiprobe entry simulator. The simulator will modulate the telemetry data onto a doppler realistic carrier for insertion into the station microwave system.

A detailed design still not settled is the signal presence indicator for the Multiprobe entry. There are currently two design alternatives. First, is a single signal presence indicator which would use an array processor to analyze the entire 2 MHz of interest at once. This approach would require a minicomputer to control the array processor and to generate operator displays. The second approach involves purchasing four or five separate spectrum analyzers for each station, where each analyzer would look at the output of a single open-loop receiver and therefore would be only 150- to 300-kHz bandwidth capability. Both systems would also be used to validate proper end-to-end operation of the DLBI system by operating either the array processor or one of the narrower bandwidth spectrum analyzers on the read-after-write output of the high-rate digital recorder.

References

1. Miller, R. B., Pioneer Venus Mission Support, *Deep Space Network Progress Report* 42-27, pp. 28-35, Jet Propulsion Laboratory, Pasadena, Calif., June 15, 1975.
2. Miller, R. B., Pioneer Venus Mission Support, *Deep Space Network Progress Report* 42-36, pp. 22-27, Jet Propulsion Laboratory, Pasadena, Calif., Dec. 15, 1976.

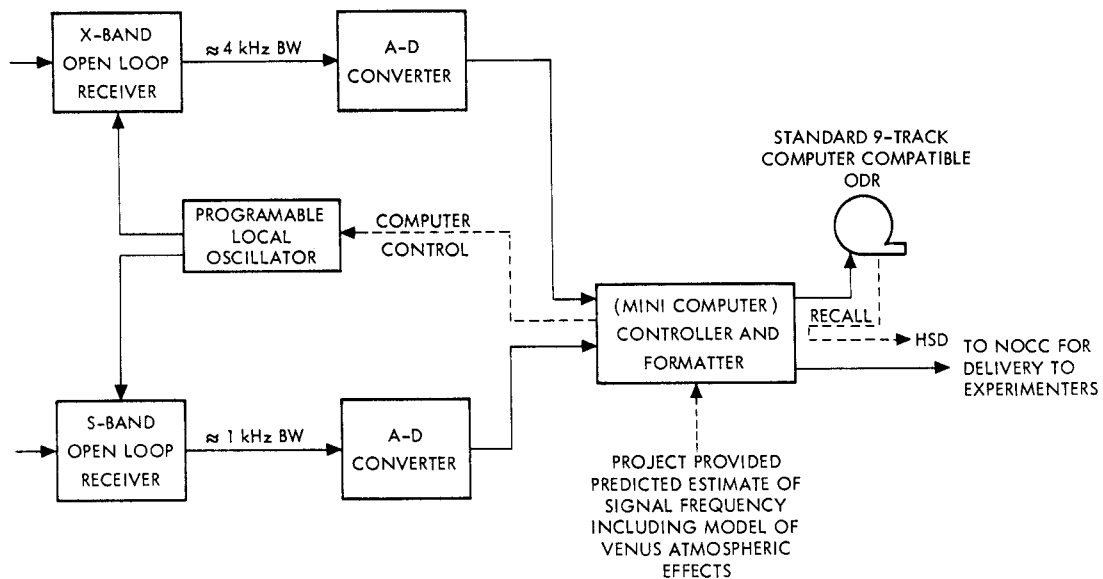


Fig. 2. DSS 14 and 43 configuration for Pioneer Venus orbiter occultation support

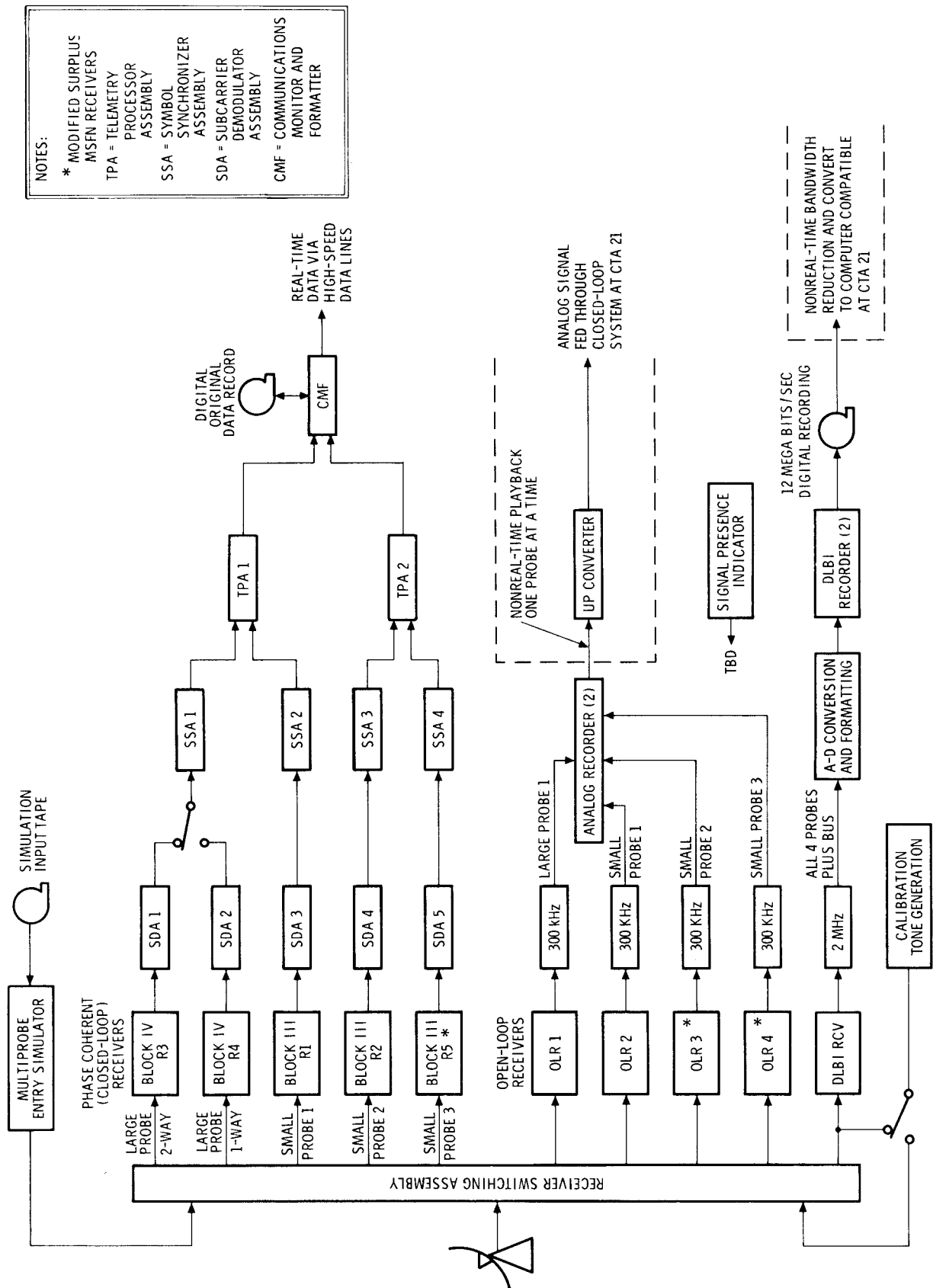


Fig. 3. Pioneer Venus 78 Multiprobe configuration for telemetry data recovery and interferometry experiment